FROM TRIREME TO TRIMARAN THE FASCINATION OF SHIP DESIGN

BY

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Introduction

Giving an inaugural lecture is a daunting task as the new Professor is not only expected to talk with the erudition appropriate to his professional standing but also with clarity and insight to a general audience. That is a difficult remit even if you are a professional academic and thus likely to be an authority in a specific field of your discipline. If instead one is a secondee, to use the civil service term, who is selected and nominated to take the Chair of Naval Architecture at UCL, then the choice of lecture subject is less obvious.

What the Royal Corps of Naval Constructors' appointee brings to the Naval Architectural Chair at UCL is expertise in ship design and, more specifically, naval ship design. That means he is a generalist in engineering terms, the expertise being in the specifics of the design of ships—hence the second part of my title to which I will return. So why the first part? I have to own up to it partly being deliberately eye catching and an alliterative device—but it is also because both the Trireme and the Trimaran have links with my two appointments to UCL and because they are very much the α and θ of ship design, at least to date.

I decided to explain my theme of the fascination of ship design through these two case studies because they enable me to draw out some threads in looking at the subject of ship design, which of course is the *raison d'etre* for the practice of naval architecture. Now I could just have surveyed the naval architectural and ship design scene or even followed on from the themes of my predecessors' six inaugural lectures. Given that I want to come back to the same concern that ran through their lectures, it is appropriate to look at each of their lecture titles:

Louis RYDILL—*What is Naval Architecture?*[1]
This was highly appropriate from the first holder of the Chair in Naval Architecture of London University.

Ken RAWSON—*Maritime Decisions, Decisions.*[2]
A typically quizzical title from a ship designer who had been very involved with the naval customer setting broader ship requirements.

Roy BURCHER—*Methods of Analysis in Ship Design.*[3]
Was the first appearance in these Inaugural Lecture titles of my sub theme of ship design. Very appropriately Roy tied ship design to analysis, drawing on his experience and deep insight in the field of ship and submarine hydrodynamics.

Louis RYDILL—*What is the Future for Naval Architecture?*[4]

On his return to UCL, Louis' second Inaugural Lecture title was much more apocalyptic than the first. This was perhaps understandable being a summary at the end of an eminent career. The latter part of his career in the MoD had been dominated by issues of change—an organizational state in which we seem perpetually fated to exist.

Charles BETTS—*Engineering Design at Sea?*[5]

This continued Louis' theme of uncertainty with a direct emphasis on ship design.

Doug PATTISON—*A Generation of Design—Ships for the Rough Stuff.*[6]

Doug restated the ship design theme with the added emphasis one would expect of a practising yacht designer, builder and sailor.

So having seen the continuity of concern with ship design, let me now turn to an all too brief consideration of my two 'T's before I refocus on the issue of ship design. In doing so there is a question which I would like to answer, namely whether a naval architect is essentially an analyst or a designer.

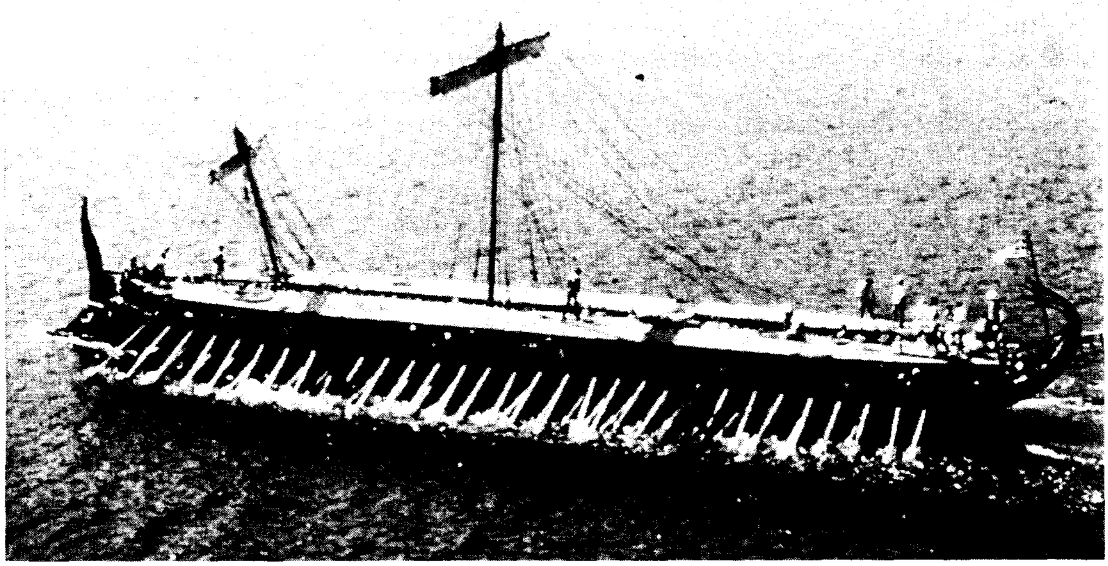

FIG. 1—'OLYMPIAS'

Trireme

I would like to commence my consideration of the Greek Trireme by recalling what a remarkable achievement it was by John MORRISON, a Professor of Greek, and John COATES, a fellow naval constructor, to reconstruct the ancient Greek Trireme and get that vessel to sea in full working order(FIG.1).

The reason why I have commenced my consideration of ship design with the Trireme is because of John COATES. John is an eminent former Chief Naval Architect of the Ministry of Defence and could quite easily have been one of my illustrious predecessors as Professor of Naval Architecture at UCL. Like a lot of naval constructors to whom I pay tribute, he has contributed over the years to the MSc course in Naval Architecture at UCL by being a visiting lecturer, an examiner and a sponsor of research. This continuous involvement by my Corps colleagues is undoubtedly a significant contribution to the breadth and standing of this course, which continues to attract students from most major naval services.

I have a particular personal link with John and through him an early awareness of the Trireme work. When I was last on the staff at UCL some 10 years ago and producing my thesis *Synthesis in Ship Design*[8], Louis RYDILL, as Professor of Naval Architecture, was my boss and thesis supervisor. He therefore had the problem of finding an appropriate external examiner for the thesis. The examiner had to be a warship designer, as that was the type of ship design I had naturally focused on, but he also needed to be of a decidedly philosophical bent, as that constituted a sizeable component in the approach I adopted. This second aspect meant that John was the obvious candidate—if that is the right term for an external examiner. He had recently retired from the MoD and, whilst intrigued by the thesis topic, pointed out he was rather busy researching and designing a 'Greek Trireme'. Like most of our somewhat prosaic or even philistine profession, I was unable to distinguish the Trireme from any other ancient galley. In fact I had a typically ignorant view that until the sail powered ships of Elizabeth's navy defeated the galleys and galleons of Philip of Spain, naval warfare had been just like land warfare—a clash and locking up of massed foot soldiers where the ships just served to bring together these bodies of men (FIG.2).

John thankfully accepted the examining role under the somewhat mistaken belief that, whilst he was travelling around the country looking for potential Trireme builders, he could read the thesis on the train. That view was mistaken because inevitably the philosophical content meant it was a far from slim volume. My excuse for this extensive thesis is that it shows how wide ranging this topic is, as it revealed, being the first thesis in naval architecture to tackle head on the nature of ship design. I also suspect its size demonstrated the difficulty of a faculty member, who was also the only Lecturer in Naval Architecture at London University, had in finding the extra time and energy required to condense it into a more transportable form.

Rather than debate ship design theory further, I would like to return to John COATES and his Trireme endeavours because I believe those endeavours exhibit precisely the qualities which are relevant to modern ship design. First and foremost he typified in this redesign and restoration project a combination of enthusiasm and complete professionalism obvious to those that have been privileged to hear John lecture on the Trireme project[9]. With so little technical evidence, John had to get to grips with ancient Greek technology and solve some significant design problems. However he knew he also had to deal with the other half of the task, that of managing the project to ensure all the technical, financial, programme and logistical issues came together on time and within the cost ceiling. I want therefore to look briefly at the engineering and the construction issues before I draw some clear lessons from the Trireme project that are wholly relevant to my theme.

So the Trireme was not any old galley that just happened to have three rows of oars—rather it was the foundation of Athens' supremacy in Ancient Greece. We think of Athens being famous as the cradle of democracy and western culture, not so in ancient times. Reference 7 quotes from a 5th Century Greek play to the effect that it was precisely Athens' skill in producing this technically perfect warship that was the specific measure of the fame of Athens. In the play, two Athenians arrive in a foreign city and when asked:

"What is your country?"

reply

"Where the fine Triremes come from".

The Trireme was the fastest type of oared ship of all time and the oarsmen were skilled and professional. The introduction of the trireme into the Mediterranean, following its invention by the Corinthian shipwright AMEINODES in about 650 BC, was comparable to *Dreadnought*'s impact on

FIG. 2—BATTLE OF LEPANTO

battleship design in 1905—rendering all predecessors—in the trireme case, the 50 oared galley—obsolete. The step change was truly immense. So it was:

- 2½ times heavier
- Had 3½ times the oars
- Carried over 3 times the complement

and, John estimated,

- 2½ times the cost compared with its predecessor.

What was it that made this ship so remarkable? Firstly the design was 'optimized' for speed. With its very long fine hull it could achieve a remarkable 7.5 knots for 24 hours (implying some 12 kW effective power) and in the dash, 9.5 knots for 5 minutes (requiring some 29 kW). Such a long fine ship optimized for the sprint speed only achieved stability due to its low displacement from a very light shell construction and the wine glass like shape of its mid section. Its structural design was equally remarkable (FIG 3). In order to achieve the length, the designer/builders exploited the absolute limit of timber's strength and John's various publications[7,9] describe the research and analysis he undertook to appreciate and replicate this. I found the most fascinating part of his research into the design to be the consideration of the hypozomata or undergirding tension ropes (FIG.4). These reduced the deck tensile stress, calculated by John COATES, to a level permissible for pine built ships of 2.9 N/mm^2. This precise level was that specified some 22 centuries later by the founder of the Royal Corps, Sir William WHITE.

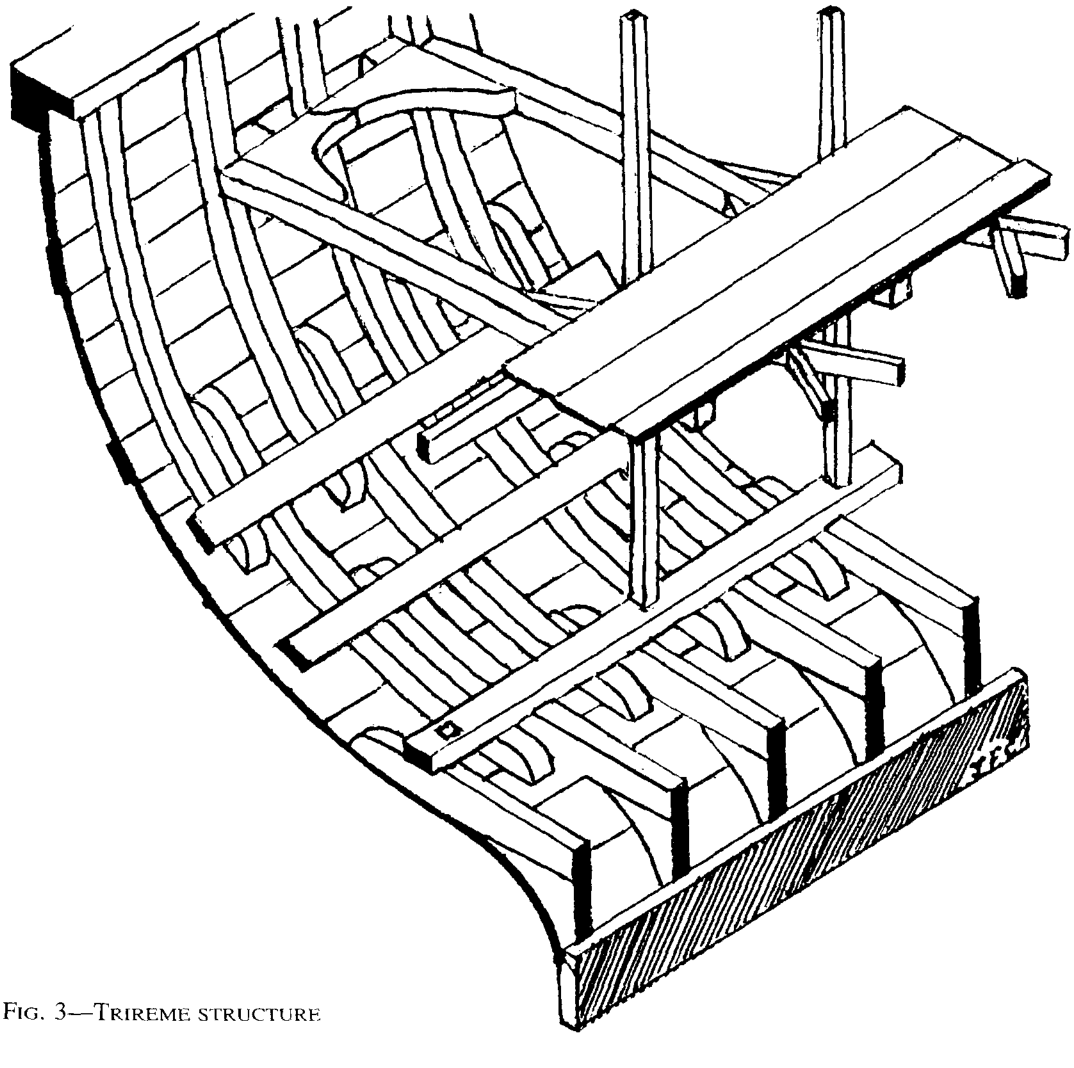

FIG. 3—TRIREME STRUCTURE

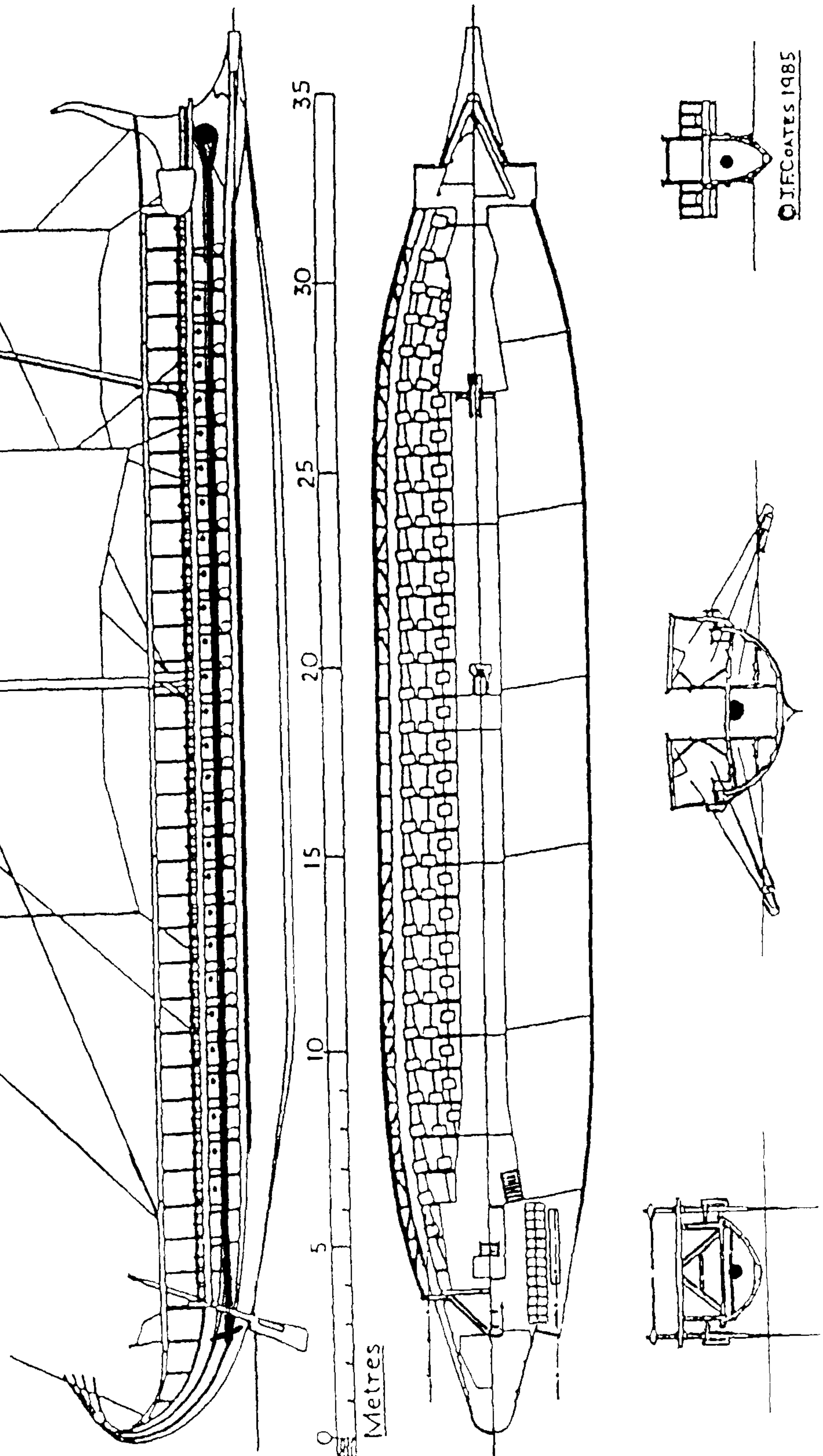

FIG. 4—TRIREME GENERAL ARRANGEMENT SHOWING THE HYPOZOMATA

Equally impressive is John's description of the task of designing and building *Olympias*. When one compares the statistics of his endeavour with modern warship construction which lasts decades and costs many tens of millions of pounds, one has to marvel at his value for money:

TABLE 1—*Trireme project*

Design effort—2 man-years.
30 drawings.
120 pages of building specification.
Total price $0.8m ($0.5m of which was the actual build).

Like all real projects there were changes made on the way and, as the Project Manager, he had the advantage of both a mock-up and then a 5m trial section or partial prototype which was rowed at Henley Regatta. Now a partial prototype is all too rare in ship design, but well justified in this instance. The only recent example I recall was that employed by the MoD to test out the basis for the first Glass Reinforced Plastic Mine Counter Measures Vessel HMS *Wilton* (FIG.5). [10]

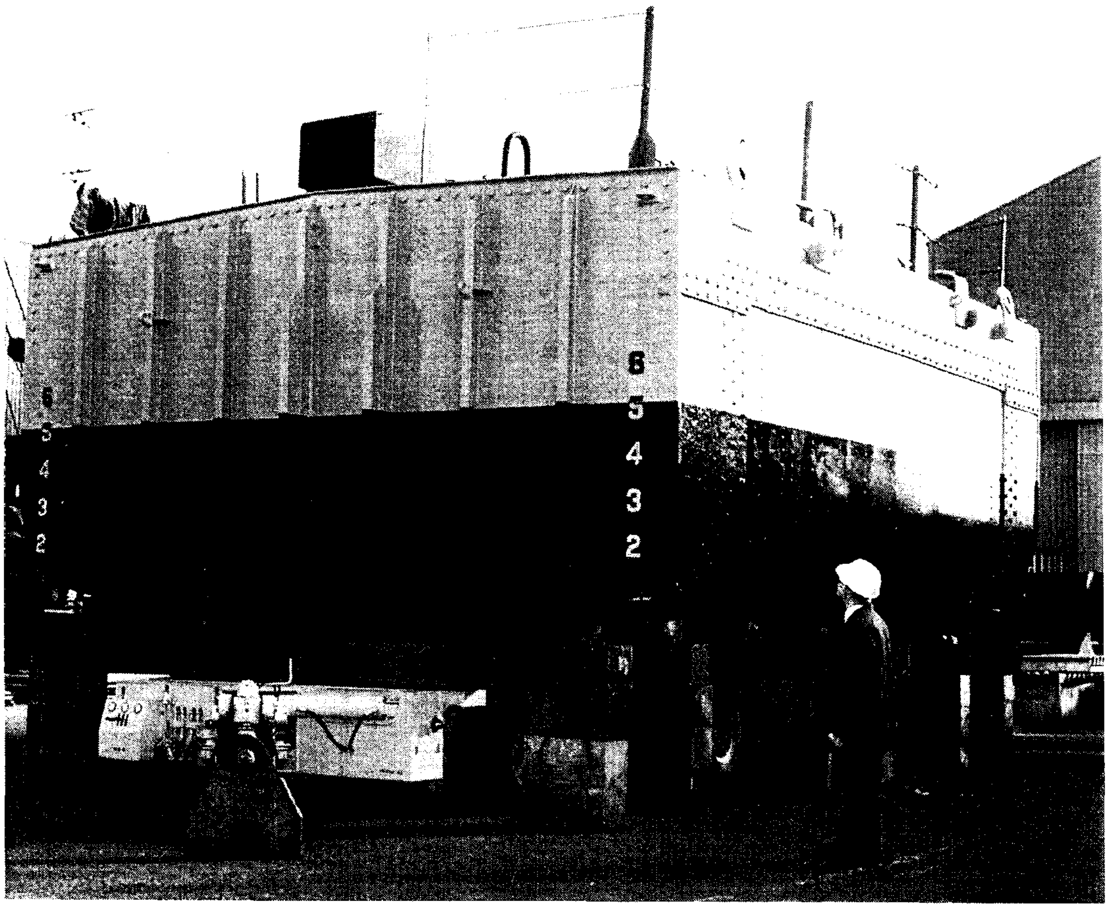

FIG. 5—TEST SECTION OF A GRP MINE COUNTER MEASURES VESSEL

I want to conclude this brief summary, taken from References 7 and 9, by drawing out some specific lessons:

Firstly

There was the interlinking of the various aspects of the project. Consideration of powering led to shape, that led to the refined structural design. Consideration of the ship's structure led to research and development in the materials employed, and that directly onto the task of constructing the vessel. This sequence typifies ship design in the round which must tie in performance, design, research and development and construction.

Secondly

The intimate linking of the task of managing the ship's procurement, from the Greek shipyard, with the deriving and developing of the design was a process that continued right through the building of the vessel.

Thirdly

Most of the technical and procurement project issues that John COATES had to deal with in producing this Fourth Century BC Dreadnought are fundamentally relevant to modern warship design and procurement in terms of standards, safety, performance, reliability, cost and programme.

Finally

As I am sure is obvious from my summary, pivotal to the success of this remarkable construction was the leadership of a fully professional and highly competent ship designer.

Trimaran

It is appropriate to commence consideration of the Trimaran with *Ilan Voyager*, the first powered Trimaran which holds the Round Britain Powerboat record due to its very low resistance. So why a Trimaran? There have been other multihull ships for many years and, for example, the Catamaran has become an extremely popular configuration for high speed ferries. But the Trimaran is different because it is essentially one large hull, very long and thin. This makes it very efficient to power with the small outriggers (FIG.6), providing the transverse stability normally achieved in a monohull by a fuller beam.

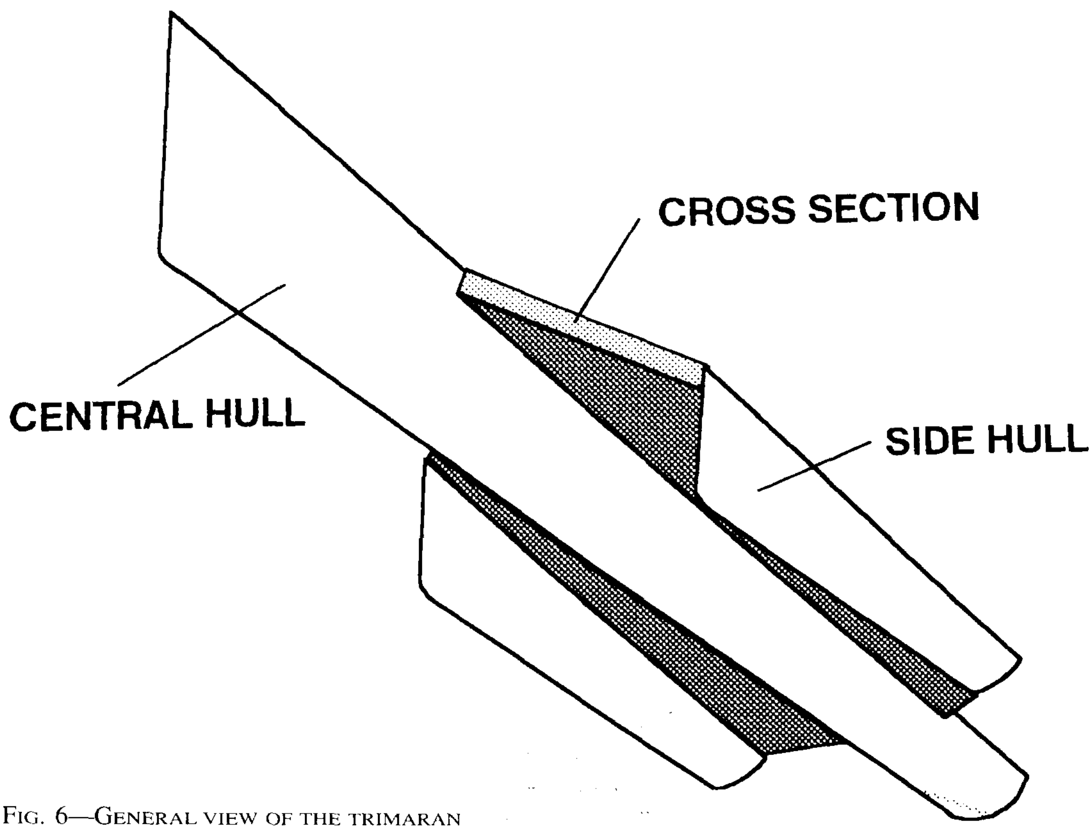

FIG. 6—GENERAL VIEW OF THE TRIMARAN

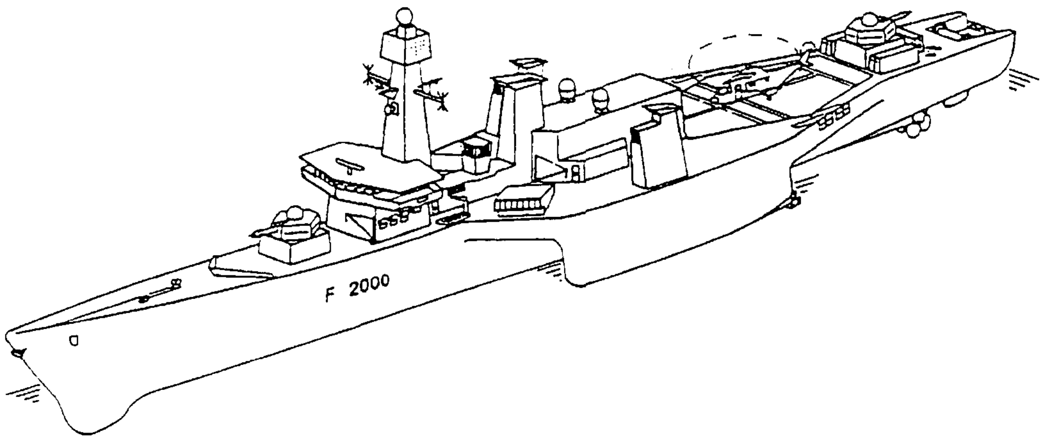

FIG. 7—THE TRIMARAN ADVANCED TECHNLOGY FRIGATE
DISPLACEMENT 4,200 TONNE LENGTH BP 148 METRES
MAXIMUM BEAM 27.5 METRES CENTRE HULL BEAM 10.4 METRES

Apart from the alliteration, what is so pertinent to Naval Architecture at UCL about Trimarans? Not only is the Trimaran the latest idea in ship shape and therefore worthy of general naval architectural interest, but whilst Nigel IRENS produced the first modern powered Trimaran, it was my predecessor, Doug PATTISON, who first explored its potential for really significantly sized ships. When Doug was at UCL, he took Nigel IRENS' configuration and got a student team to design an advanced technology frigate which was produced in 1990 (FIG.7). One of the exciting things to inherit, when I took over at UCL from Doug last summer, was his research programme into trimarans. Because he had initially explored the concept through MSc student ship designs, I was already aware of the Trimaran concept. This was because I was then the Head of Preliminary Design in Bath. My remit was therefore to consider all options for new naval vessels, even brand new concepts such as the Trimaran and the UCL student designs provided a useful means of exploring new ideas.

So let me now look at the Trimaran as one possible vision of the shape of future ships and therefore an excellent case through which to explore the fascination of ship design. Doug and his collaborator Jun-Wu ZHANG, now one of my Research Assistants, recently produced the first technical paper on trimaran ships.[11] It describes the UCL ship design studies and the technical issues already considered. It is convenient to consider these firstly under the three main discipline headings adopted at UCL in the taught part of the MSc in Naval Architecture,[12] namely:

- Ship Hydrodynamics
- Ship Structures
- Ship Dynamics.

Hydrodynamic behaviour of the very slender central hull is the primary reason why the configuration is of interest. Unlike *Ilan Voyager*, a frigate a thousand times heavier will not skim over the water and so however fine it is, a trimaran ship will need comparable power to a monohull to drive it through the sea. The trick, whilst being roughly comparable, is to be a significant amount less as is shown by (FIG.8) where the Effective Horsepower (EHP), or the useful work necessary to propel the ship, is plotted against increasing speed. As can be seen from the shaded band, we are still cautious in predicting just how much less resistful the trimaran ship will be. Nevertheless, it is likely to be better than any current warship and even the

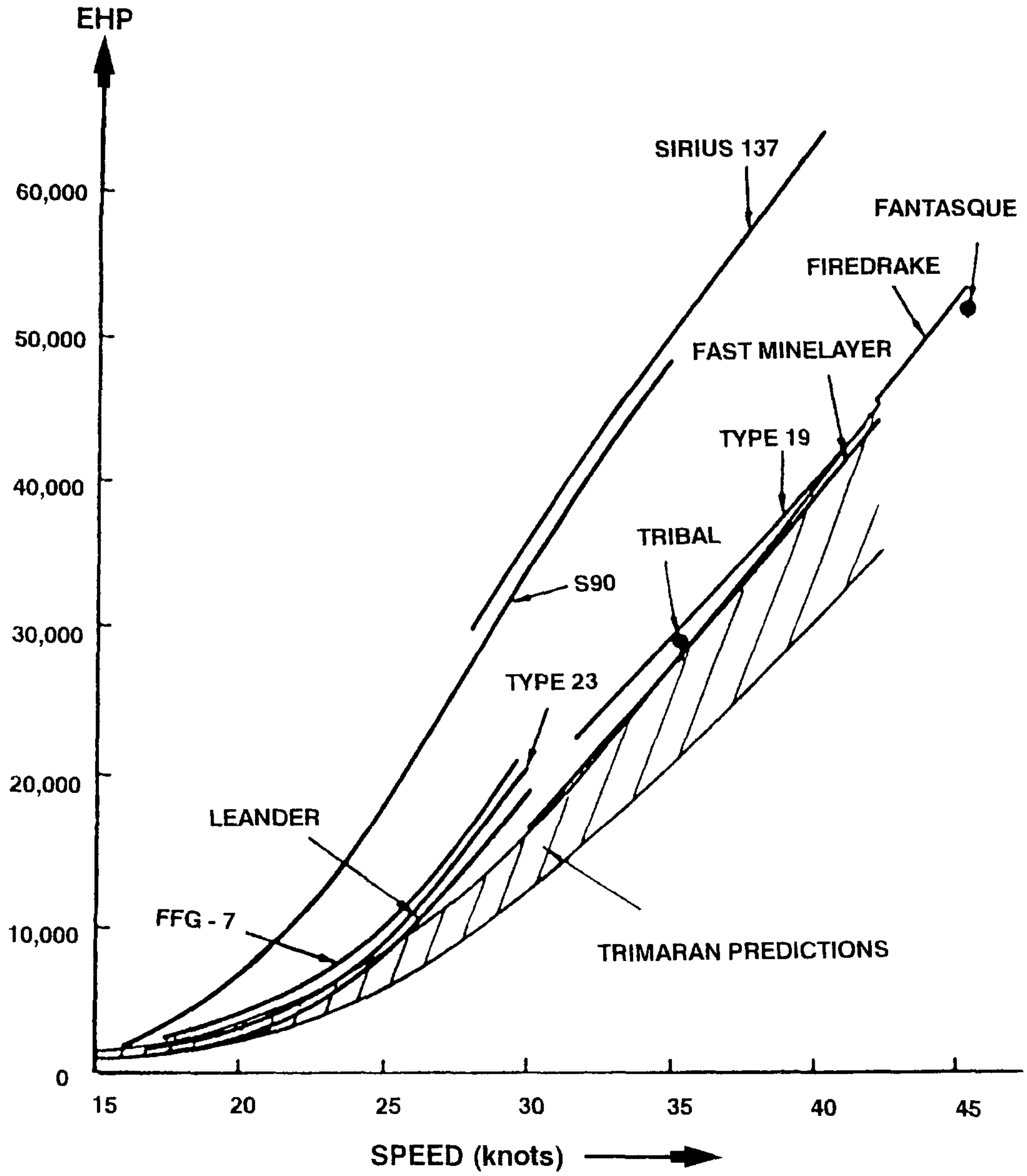

FIG. 8—PLOT OF EFFECTIVE POWER AGAINST SHIP SPEED (REF. 11)

very fast destroyers and minelayers operating at the end of World War 2, which were optimized for high speed. As for the S90 and *Sirius* proposals of short and fat infamy, the real question is why this configuration was ever raised as a possibility for frigates. But that is a topic for another lecture or even a thesis on technology and its Cinderella status in decision making in this country.

Now there are a lot more hydrodynamic issues to be explored beyond our initial need to conduct resistance model trials with the 6m trimaran model hull form, based on the design by Jun-Wu ZHANG,[13] which is being tested at the Defence Research Agency's facilities at Haslar. For example there is the need to explore the effects of the side hulls:

Should they be made to set up beneficial wave cancelling systems?

Should we alter the hull form so that both the main hull and the side hulls are wave piercing like the latest cross channel catamarans?

Should there be auxiliary propulsive devices in the side hulls to provide redundancy and enhance manoeuvrability?

These are just some of the issues suggested by the novel configuration.

On the strength side, the novel feature is the large deck linking the three hulls which thus provides much more utilizable weather and main through decks than is possible in a conventional frigate. Given their small size and the relatively low loading on the side hulls, trimaran structural design seems akin to a mono hull. The latter is idealized as a long beam bending under wave action whilst, for example, the structured design of the Small Waterplane Twin Hull (SWATH) configuration is dominated by the effect of the side prying loads on the cross structure (FIG.9). But in truth we do not yet know for certain and, given the complex loading imposed by the sea on a ship, there is a substantial area of future research before we have available sufficient guidance for the designers of future trimaran ships.

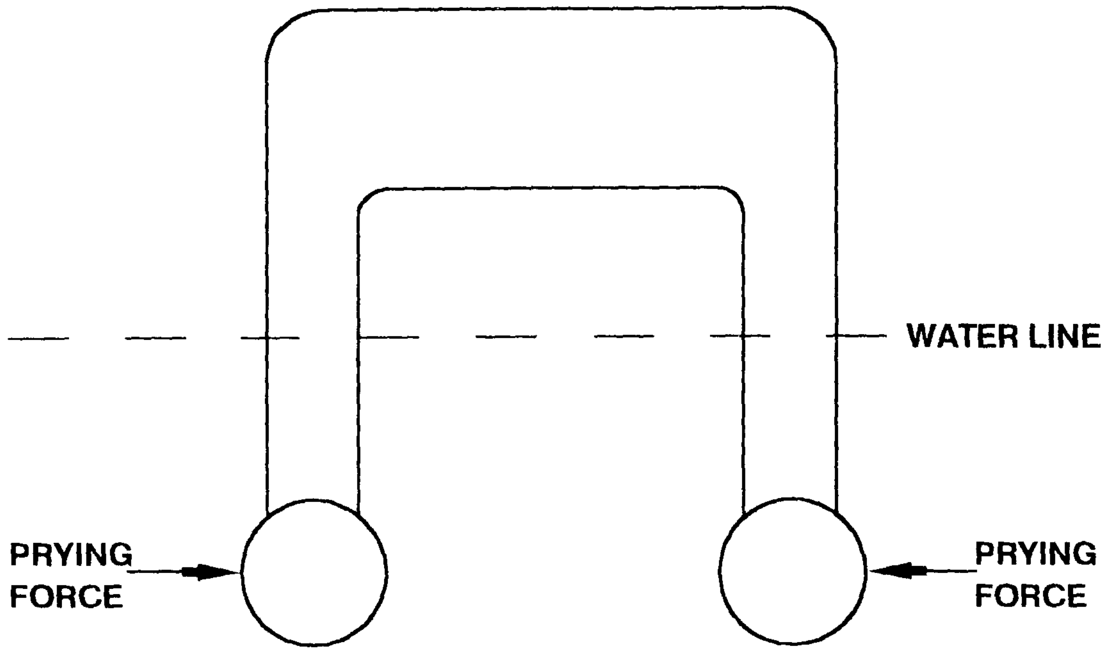

FIG. 9—THE EFFECT OF TRANSVERSE LOADING ON A SWATH VESSEL

The third heading of ship dynamics covers not just seakeeping—namely the response of this new ship configuration to the excitation of the random and demanding sea environment—but also the real loadings of those seas and the complex response of trimaran structure to these loads. This latter topic of structural dynamics applied to marine structures is very much UCL's special contribution to naval architecture. It was started by the late Dick BISHOP,[14] who brought the RCNC and naval architecture to UCL. That approach continues to provide insights into the behaviour of traditional ships, offshore structures and unconventional hull forms such as the trimaran. The focus of our current trimaran analytical research with DRA Haslar is on the response of the model shown in (FIGS.10&11) to wave action, both its seakeeping response and the structural loadings imposed on it.[15]

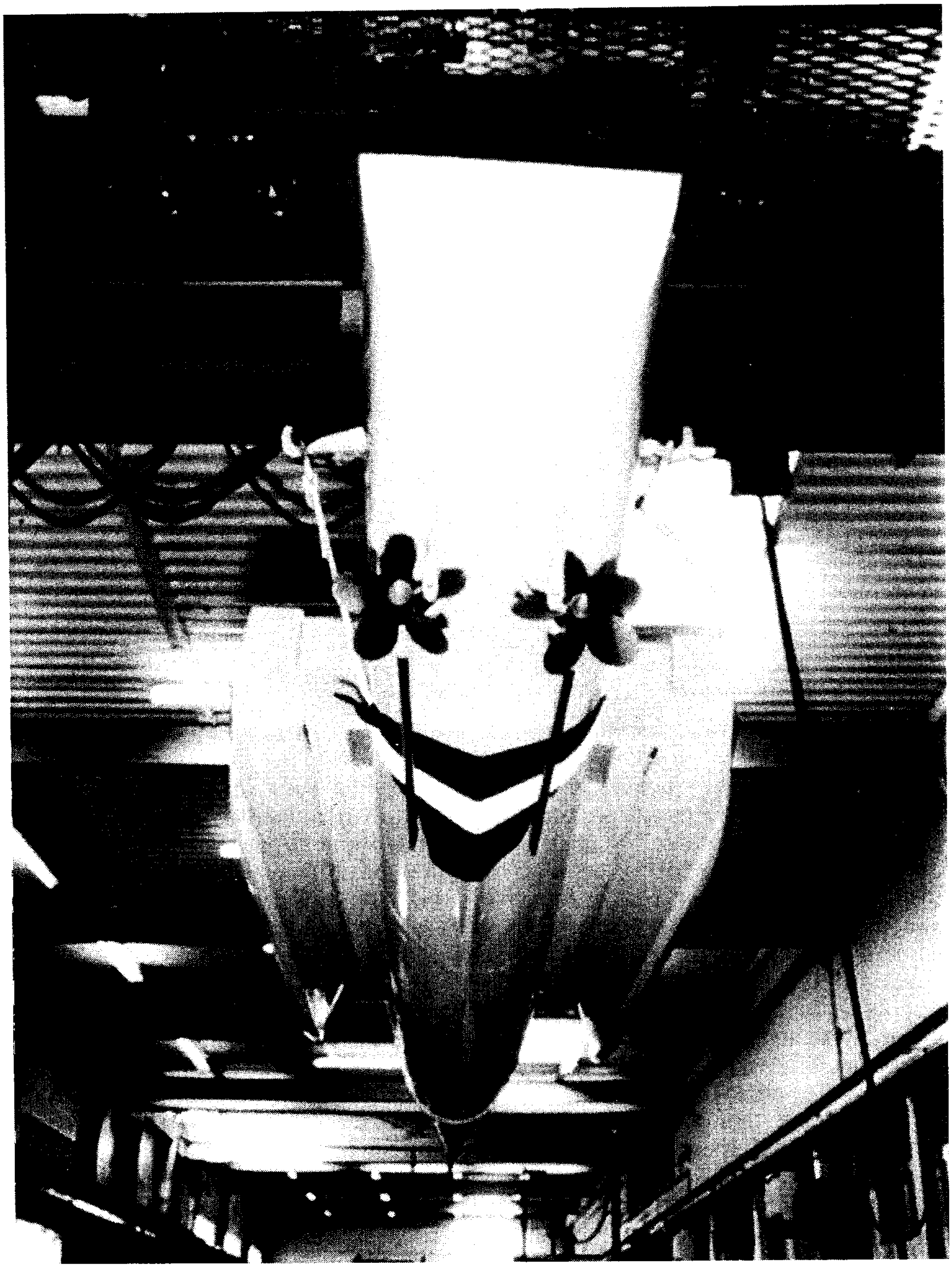

FIG. 10—DRA'S 6 METRE TRIMARAN FRIGATE MODEL

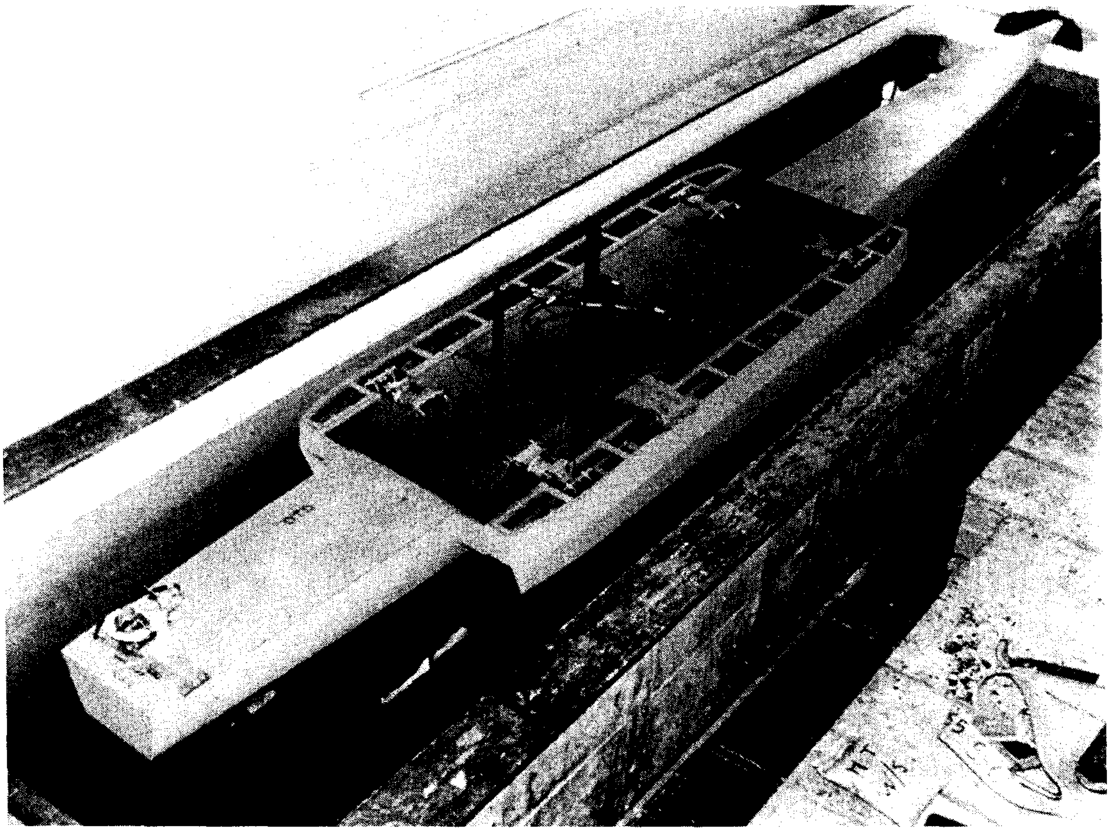

FIG. 11—DRA'S 6 METRE TRIMARAN FRIGATE MODEL

Now what I have described so far are largely very absorbing problems which are typical of naval architectural research practised at universities and research establishments. By that I mean the application of applied mathematics and the laws of physics to our new problem of the trimaran hull form—but is it design? I have to say it is only so to a degree. Design is relevant in tackling the interrelationship of issues, which at a research level are generally explored in separate discrete investigations. In reality, all these issues are highly interrelated so that for example, if we find that the size and separation of outriggers chosen for our Haslar model leads to a resonance in roll at a frequency likely to be experienced at sea, then the side hulls' configuration will have to be changed. This could alter the trimaran's resistance which could mean that to achieve the speed required, bigger engines are necessary, and that will drive up the size of the ship. Changing the hull separation would also alter the stability of the ship which would mean further changes to the side hull forms. These could alter the ship's manoeuvreability requiring bigger rudders and weakening its structural strength. This would require more strengthening, thus increasing the weight of the ship and hence its displacement, its resistance, its engines, the fuel carried, its size, its weight etc. (FIG.12). So before you know where you are one aspect of research output could, for example, mean that our original design, which looked highly advantageous, may no longer be as attractive an option for the frigate of the 21st century or the next super North Sea ferry.

One aspect which links many of the research and design issues is that of configuration and in the case of the Trimaran reveals a major advantage it has over the traditional frigate. In a long and narrow frigate, the competition is intense in locating the various compartments so that the most important can be placed in the middle of ship. Furthermore modern frigates deploy large sophisticated helicopters which end up having to land on the stern of

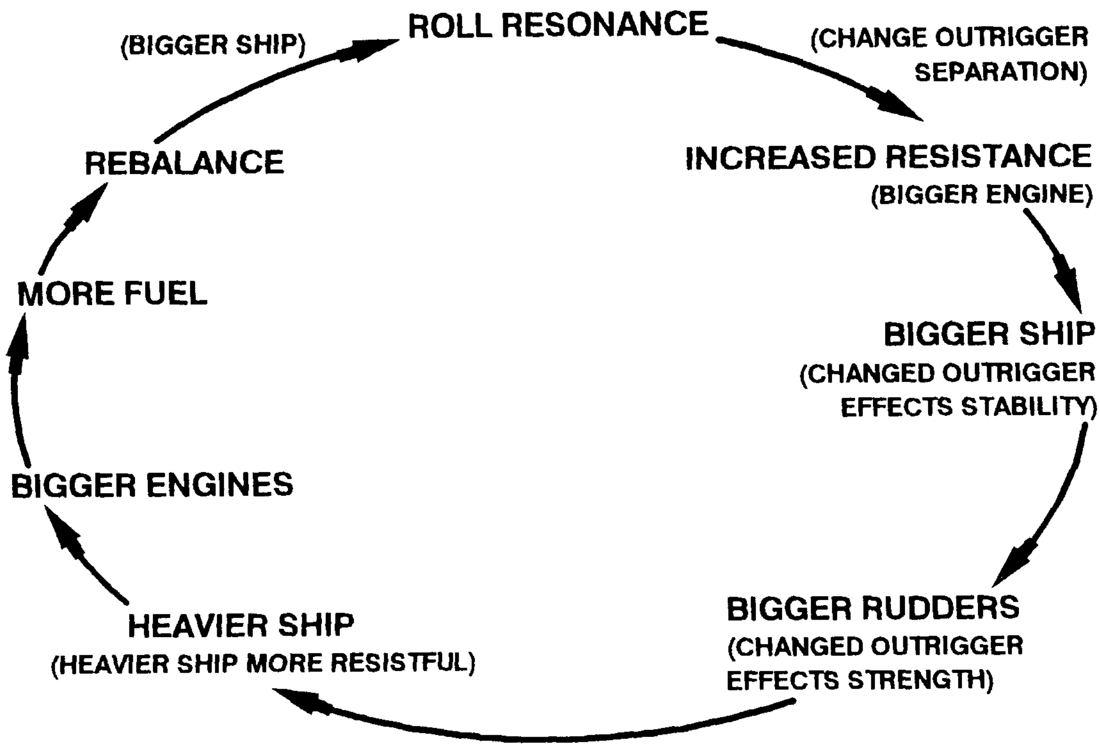

FIG. 12—A SIMPLIFIED SCHEMATIC OF A TYPICAL DESIGN SEQUENCE

the ship. I recall vividly from landing in a WASP helicopter on a LEANDER class frigate off Iceland, that such operations are far from risk free experiences. So our trimaran presents the ship designer with a nice wide main through deck where the important working spaces can be better accommodated (FIG.13). Secondly, with this wide upper deck amidships, it is much easier to bring the flight deck and the hangar to a location where the ship's motion is least. This means the helicopter can operate more safely for more of the time.

Now this whole issue of the arrangement or, as I would rather call it, the architecture of ships is one that a new configuration, such as the Trimaran, brings into sharper focus. Given that this is precisely the area where I conducted my research when I was last at UCL,[16] I am already exploring this with regard to the Trimaran. What such a focus does is to bring into prominence some aspects which are vital design issues, but which traditionally have not figured primarily in academic naval architectural research. Aspects such as survivability—the ability of a ship to resist damage, which is a distinct possibility in future peacekeeping and intervention operations, and that of signature reduction, achieved in part by sloping the hull and superstructure. Finally, in these vital issues there is a term I coined with David BROWN some years ago as Style.[17] This issue is typified by Rowland BAKER's Canadian *St Laurent* design of the 1950s. Style is far more than aesthetics, though that may be all that is immediately apparent. It covers the broad intent of the design solution and the way many aspects are integrated together. All these require a graphical or architectural ship description to reveal their relevance in the design.

So, to conclude on the Trimaran, it is not just a fun topic of research but a configuration and whole ship concept that justifies exploring all these areas of research so that meaningful and convincing design proposals can be con-

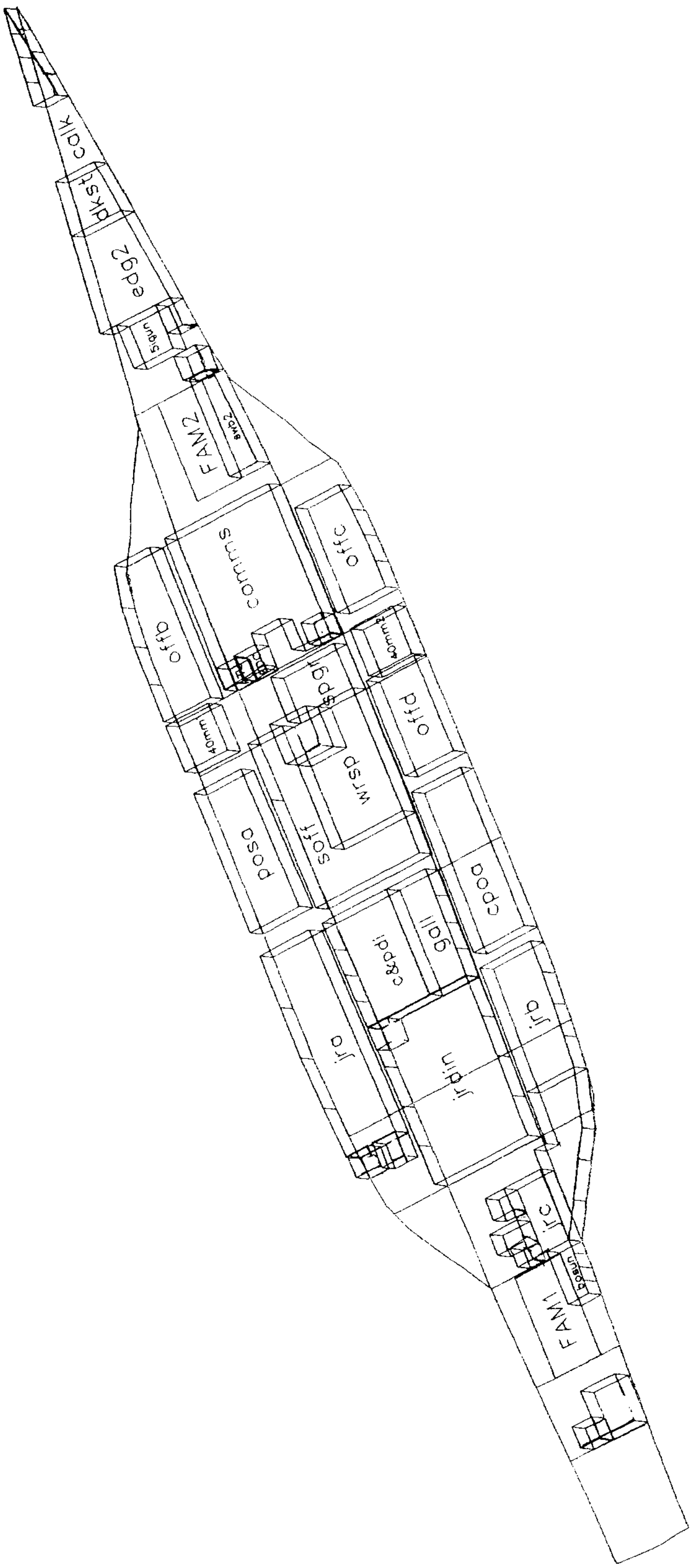

FIG. 13—DECK 2 CONFIGURATION OF A TRIMARAN FRIGATE

sidered. Thus we will be exploring further Trimaran ship designs at UCL and conducting research, not just into the traditional three discipline areas, but also into Trimaran ship design itself.

Ship design or analysis

My first example, the Trireme, highlighted some of the continuing issues in marrying the discrete naval architectural technologies with overall ship design as well as the fusion of ship design with procurement management. From the Trimaran—very much the current leading edge of ship research—the message I take is that, whilst there is considerable research to be done on the various technologies and in the naval architecture discipline areas, the real challenge lies with the overall ship design task, in pulling it all together. I believe it is therefore appropriate, in considering the relationship between the core academic disciplines in naval architecture and the role of the ship designer, to look briefly at the state of the art in the three discipline areas we teach in the MSc.

Hydrodynamics

This is the traditional discipline of naval architects, based on William FROUDE's great founding research and methodology. However, the current research thrust lies with Computational Fluid Dynamics (CFD) which is a fluid equivalent to the finite element analysis now applied to ships and other structures as a matter of routine. In the case of CFD it is the fluid surrounding the body rather than its own structure that is fragmented into a large number of discrete elements. The behaviour of the elements is analysed using the power of the computer, but only provided the analyst models his problem sensibly. This CFD approach is being used at UCL to predict the Trimaran's behaviour to compare our prediction with the performance of the model at Haslar.[18] I want to make just two points:

1. To emphasise the fact that this computational fluid dynamics approach is in its infancy and even when it becomes a mature design tool like structural finite element methods, we will still need to bench mark novel analyses with physical model testing. Let me quote a very pertinent aphorism I first heard from another former UCL incumbent, Rodney Eatock TAYLOR—now Professor of Mechanical Engineering at Oxford:

   'No one but the analyst believes his results, everyone but the experimenter believes his'.

2. CFD holds out the promise that in future there will be a greater interplay in the evolution of the hydrodynamic form and the ship or submarine's internal configuration. This is due to the graphical capability of modern Computer Aided Design tools.

Ship dynamics

Whilst rigid body dynamics continue to provide the designer with analytical tools on seakeeping and manoeuvring, the compliant structural response approach now interfaces very directly with CFD. Within the Mechanical Engineering Department at UCL, with the Ocean Engineering side of Naval Architecture being led by Minoo PATEL,[19] the read across to novel ship design, continues to be fostered.

Ship structures

Of our three core disciplines, that of ship structures has had the comparable analytical tool of finite elements for over twenty years. Even so structural design is more the bread and butter work of so many young naval architects and where they produce and subsequently check and modify detailed ship structures and so learn their trade. Furthermore, in ship design it is in this discipline that problems arise due to the conflict of structural continuity and integrity with the configurational demands of a workable and efficient layout or architecture. So here there is a direct interaction between design and analysis.

I hope this all too brief survey of the major disciplines which we focus on in the Masters course has highlighted their intimate relevance to ship design. This all comes to a head in the ship designs the students undertake after they have, hopefully, mastered the disciplines and when they, and we, can explore some radical configurations such as theTrimaran. Much though I would like to expand on the issue of the nature of design and its particular and very demanding manifestation that is ship design,[20] I will instead conclude this section by looking at the two ship design oriented areas of research that are under way in the UCL Naval Architecture Group, alongside the Trimaran research.

The initial creation of an artefact, particularly something as complex as a modern naval vessel, is clearly the most crucial and, I would contend, most creative step in what is a long, perhaps too long, process. This early step is characterised by being the engineering part of a dialogue with the intended recipient—the Naval Staff. It is up to the ship designer to ensure the dialogue explores as wide as possible a range of options, not just in the capability of the ship (e.g. its speed, aircraft, missiles etc.) but also in the solutions to meeting that capability. In exploring both conventional ships and more radical possibilities, such as the Trimaran or the SWATH, many of the issues that matter to the naval staff are revealed through the ship's architecture.

I have argued for many years [21,20,22] that, with the graphical capability of modern computers, the initial definition and this early dialogue would be best facilitated by an initial synthesis that builds up the component 'building blocks' on the screen. With such an approach the ship designer is able to produce a definition that gives prominence to those issues of survivability, signature and style that I referred to earlier. Whilst I was leading the Preliminary Design Group in Bath a start was made on this approach for submarine preliminary design. (FIG.14) shows a simplified schematic for the BMT, now Kockums Computer Systems (UK), developed SUBCON System. This summarizes the building block-based, functional and architectural synthesis which we are now exploring at UCL for surface ships, be they mono or multihulls.

As the design develops, the need to have more graphical definition grows and, whilst modern CADCAM systems are essential to define the end product, there is a need to deal, from the earliest definition of a new ship, with the other major aspect of the naval ship—its combat system. Much of the design problem in ship design lies with this interface and nowhere is this more complex than on the upper works, the superstructure and the weather deck, where the conflicts and competition for prime sites is almost unresolvable (FIG.15). Signature issues, such as minimising radar cross section, and the mutual interference of radars and the plethora of communications antenna all conflict with seamanship issues of visibility from the bridge, access in and out of the ship and the need to get stores and fuel rapidly into the ship whilst under way. These topics are but a cursory summary of the many design issues. Again the graphical capabilities given by modern computer systems seem to me the only hope for the ship designer of tomorrow to cope with all these conflicts. So this is the third area of ship design oriented research that we have started looking at and which we hope to incorporate into the teaching and the ship design exercise at UCL.

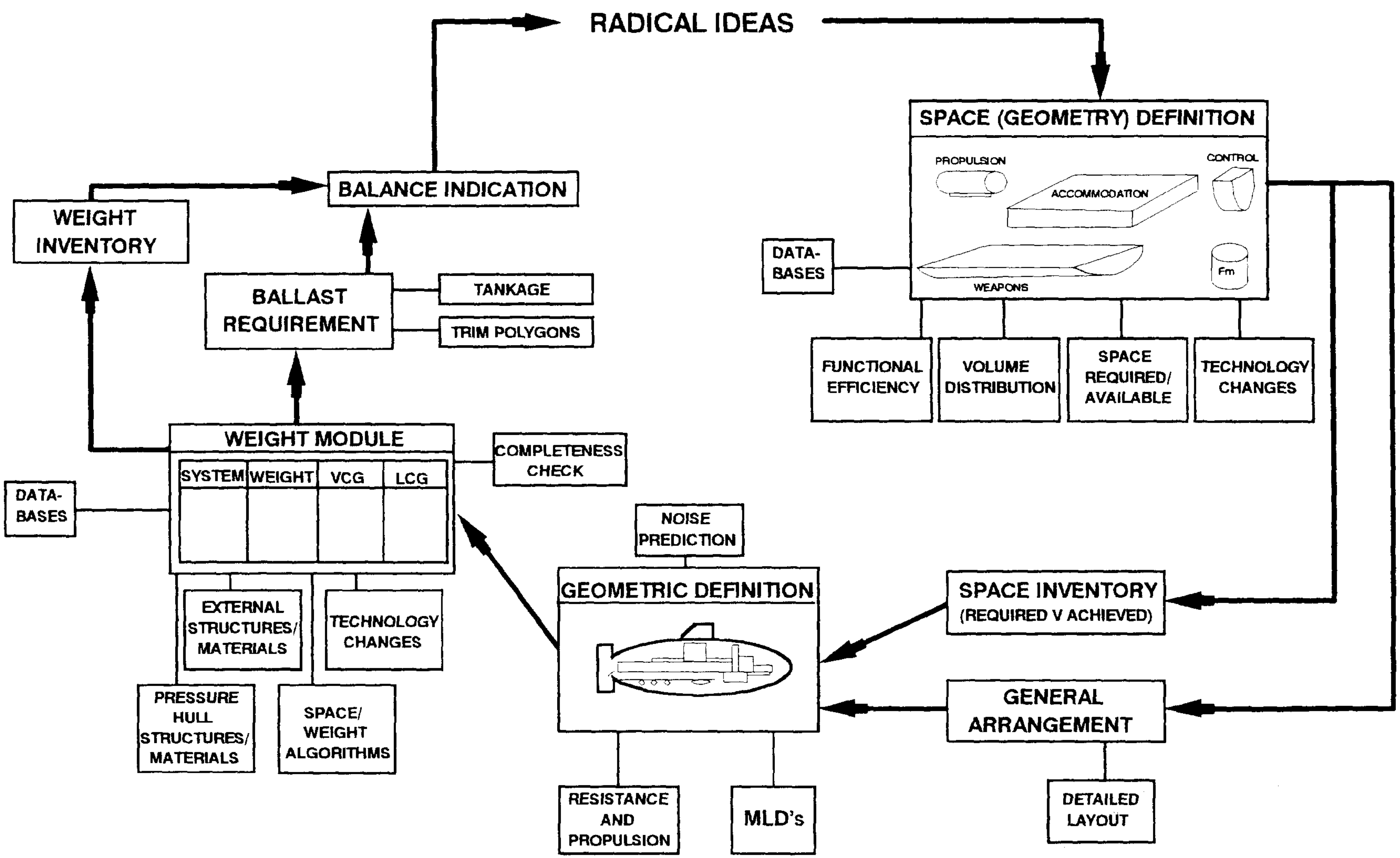

FIG. 14—SIMPLIFIED SCHEMATIC OF THE SUBCON CASD SYSTEM

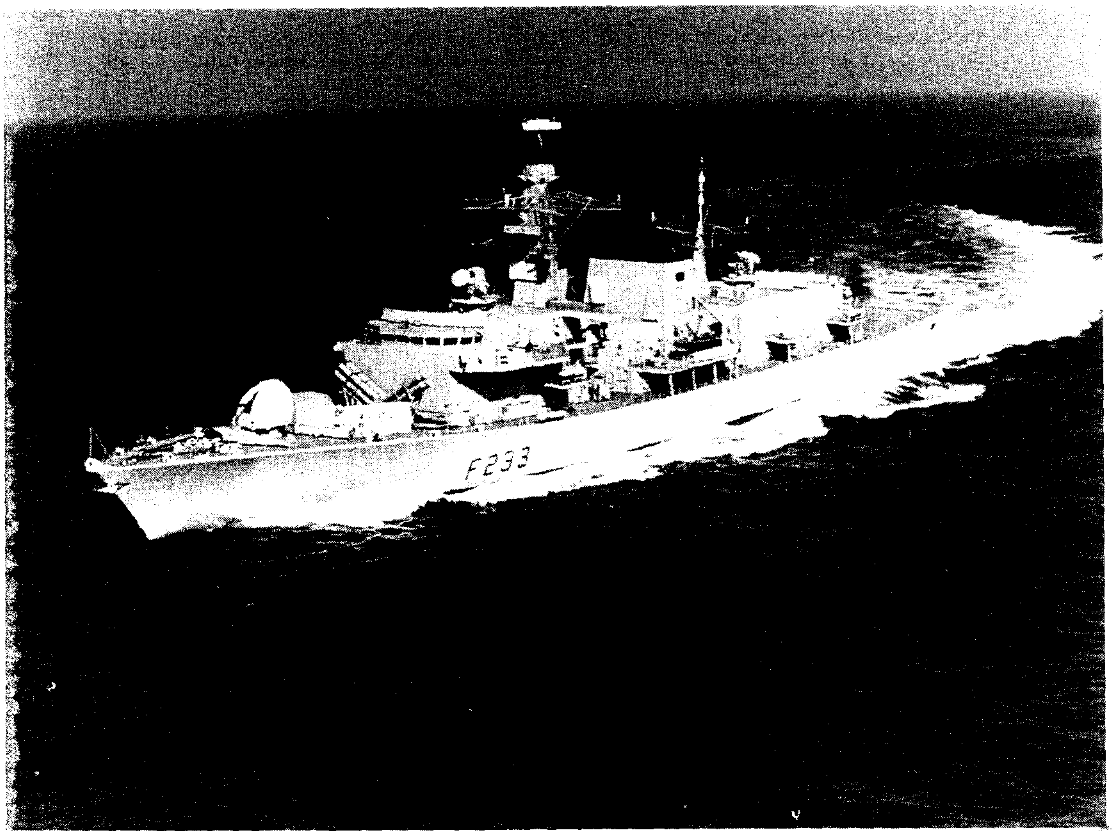

FIG. 15—THE UPPERDECK AND SUPERSTRUCTURE OF HMS 'MARLBOROUGH'

The ship designer or analyst

I would like to conclude by coming back to the reason why a practising naval ship designer is appointed to this, the only chair in Naval Architecture at London University. Essentially, I am here to train future naval architects primarily in naval ship design. These future naval architects must be fully professional, in that they must have both knowledge and skills in the component discipline areas exemplified by the work we are now doing into the new configuration of the Trimaran. But equally they must have the design creativity and whole ship systems management skill, so well exhibited by John COATES on the Trireme Project.

So we need to produce naval architects with firstly strong analytical capabilities provided through the depth of expertise of the Department's professional academics. But the MoD and the many other navies that continue to send students to the Masters Programme do not need their naval architects to be deep experts in these fields of hydrodynamics, dynamics and structures. Rather they need to have an ability that the naval architect should demonstrate above all other engineers, namely an overall feel for the total product. With sufficient in-depth understanding they can communicate with the individual experts and assess their contribution to the overall ship design, whilst still seeing the wood for the trees. Thirdly, our students appreciate through the superb teaching and learning tool of the ship design exercise, the full range of design issues. Thus they should be able to place the analytical, and the not so analytical, issues in the overall ship design context. By applying our growing number of computer aided design tools they will learn where these powerful aids can assist but also appreciate that fundamentally they are just tools. The best of these tools require the judgement and experience of a fully rounded ship designer to get the best out of them.

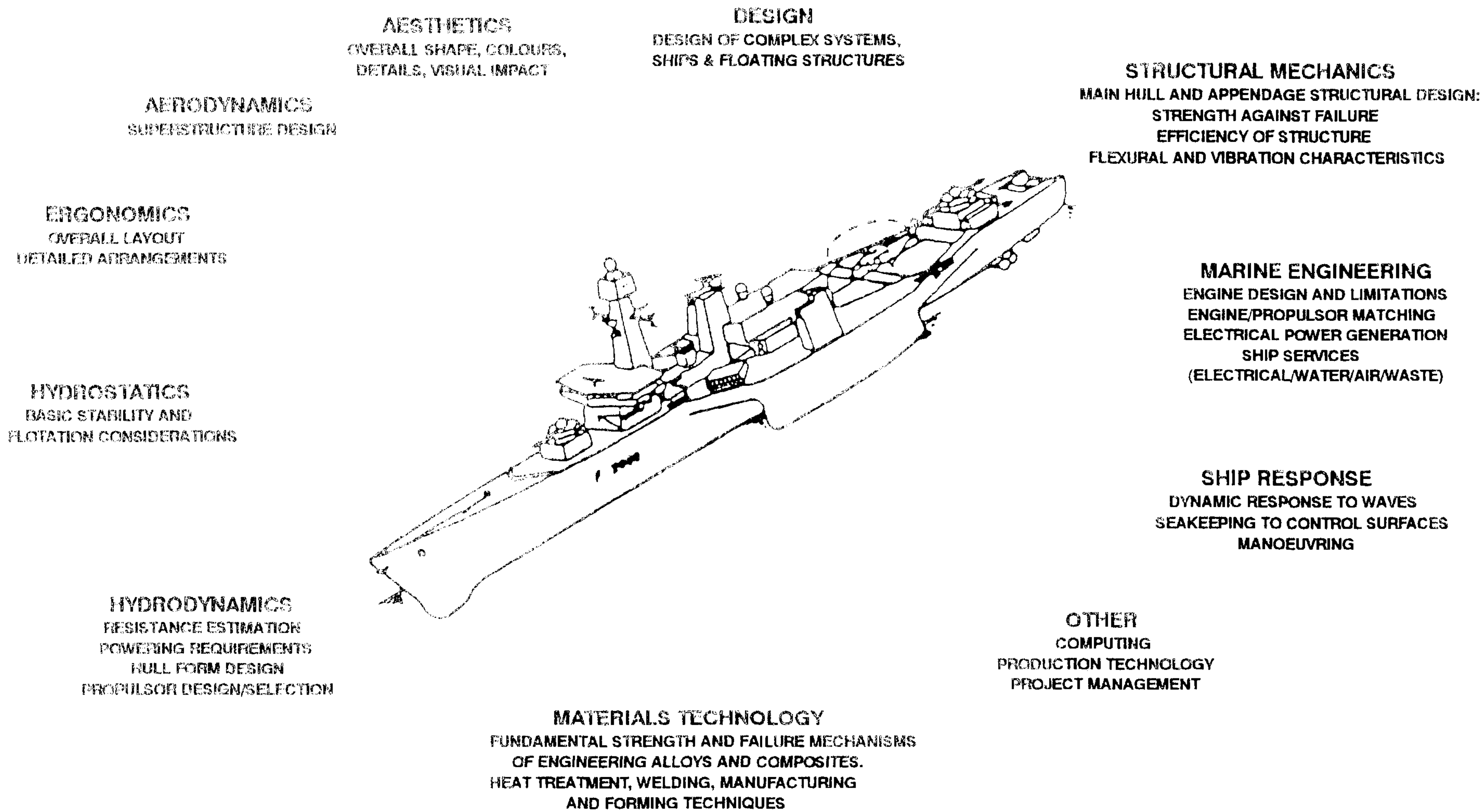

FIG. 16—AN INDICATION OF THE VARIOUS ISSUES RELEVANT TO SHIP DESIGN

So my posing of the analysis/design dichotomy was really a false challenge because the fascination of ship design is in the blending of these two elements, just as the ship is created by blending together the various features that go to make up the ship to meet the many demanding characteristics required of it (FIG.16). Whilst I have focused on preliminary design, I also deliberately chose and emphasised the project management element as part of the overall design responsibility. Ship designers were project managers and systems engineers long before either of these titles were conceived, [23] So provided we continue to draw young people into naval architecture and imbue them with the fascination of ship design, then I can feel confident in sustaining the conclusion of my predecessors, that naval architecture will continue to flourish at UCL.

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